APPENDIX 7-E

RECOMMENDED SAMPLING AND ANALYSIS PROCEDURES

SOIL SAMPLING

The objective of soil sampling is to determine whether or not soils have been contaminated, and, if so, to determine the source as well as the horizontal and vertical extent of contamination. There are two basic techniques for soil sampling. Samples can either be collected with some form of core sampling during drilling of boreholes, or they may be collected from excavations or trenches in which the samples are cut from the soil mass with hand-held corers. In cases in which the UST has been excavated, the latter method can be used. If the tank remains in place, samples should be taken with the use of drilling equipment. In either case, the goal is to obtain the most accurate representative samples possible by causing the least disturbance of the soil and thus avoiding the loss of volatile constituents.

Factors likely to influence the magnitude of the sample collection error for soil sampling are sample size, collection methods, and frequency of sampling. The most important of these are the methods for collection and the frequency of sampling. The tools used for collecting soil samples are limited and are not likely to be sources of error. The errors most likely occur in the use made of the sampling equipment. Proper replication of soil sampling procedures should ensure that the data obtained meet the QA/QC objectives.

The following procedures are recommended for sampling of soils at UST sites.

1. Prior to the initial sampling location and between subsequent sampling locations, decontamination procedures should be adhered to closely to prevent the introduction of contaminants by the sampling equipment. The decontamination procedure consists of the following steps:

    a. Steam clean or scrub all equipment with a non-phosphate detergent.

    b. Rinse with tap water.

    c. Rinse twice with de-ionized or distilled water.

2. Soil samples collected from a backhoe excavation, the ground surface, soil stockpiles, or a manual soil coring device are collected in a thin-walled stainless steel or brass cylinder at least 3 inches long by 1 inch in diameter that has been prepared by the laboratory doing the

analysis or by the sampling team. (Cylinders can be made to fit inside the preferred split-barrel or split-spoon core sampler.)

After retrieving the sample, record the soil type, depth, sample location, general subsurface stratigraphy, and ground water depth if appropriate, and any other pertinent features in the field notebook. Also note the presence of hydrocarbon vapors or visual staining of the soils in the field notebook. The soil sample may be screened in the field for an initial determination of the presence or absence of contamination, or an order-of-magnitude estimate of the contamination level, depending on the field screening equipment used. A discussion of the use of field screening equipment is included below. Based on the results of the field screening, samples can be selected for analysis in the analytical laboratory.

The minimum sample volume required is specified by the analytical laboratory based on the selected method and required sensitivity of the analysis, and should be verified with the laboratory to ensure that adequate sample volume is obtained.

In situations where the above procedure is inappropriate (i.e., semisolid samples), glass vials with Teflon seals and screw caps should be used.

3. Borings should be made under the direct field supervision of a qualified engineer, geologist, or soil scientist. While drilling to collect soil samples, data on the subsurface environment is collected by this field inspector. This information is organized into logs for each boring performed. Each boring log should contain the following information:

    a. Drilling company
    b. Location
    c. Date drilled
    d. Total depth of the hole
    e. Diameter of the hole
    f. Drilling method
    g. Sampling method

    Each boring log should also graphically present information on:

    a. Soil types
    b. Depth from surface
    c. Location of sampling sites in relation to USTs
    d. Location of groundwater table if encountered
    e. Any unique subsurface features

Descriptions of the soil classification and notes of specific observations of subsurface conditions including soil structural changes, stratigraphy changes, the presence of rock, sand or gravel lenses, root channels, animal burrows, and debris should also be included in the boring log. The Unified Soil Classification System (USCS) is recommended.

An example boring log is shown in Figure 7F.1. Quality assurance can be maintained by periodic audit of the forms and by proper training of the personnel preparing the forms. Properly prepared boring logs are one of the most valuable interpretive tools developed during an investigation.

4. Caution should be taken with regard to drilling through aquitards to avoid unnecessary vertical spreading of contamination. The ground surface immediately around the borehole site should be covered with polyethylene sheeting to prevent mixing of surface and subsurface soils. All borings not used for monitoring well installation should be backfilled with uncontaminated drill cuttings or clean fill cupped with a bentonite seal.

   Note: The State Water Commission fo the Hawaii Department of Land and Natural Resources has set forth procedures for well abandonment in HRS Title 13, Chapter 168, Section 16. Owners and operators and their consultants/constractors should contact the State Water Commission to determine what requirements may apply to their site.

5. Soil samples are to be taken at the depth interval indicated on the boring log. Typically soil samples should be taken from the borings at consistent intervals of 5 feet. If greater sample control is needed or desired, sample intervals should be adjusted accordingly. Sampling procedures are as follow: 1) drill to the prescribed depth; 2) place the stainless steel or brass liners into the split-spoon sampler; 3) assemble split spoon and attach to drive assembly; 4) drive into formation, noting blows per l/2 foot on the boring log; and 5) be aware that soil material initially outering the sampler may represent sloughed sidewall material.

   Note: Generally, three liners are placed in the split-spoon sampler. The middle liner should be used as the primary sample, as the objective of the soil sampling procedure is to obtain the least disturbed samples possible. The bottom liner in the split-spoon sampler may be collected and capped for use as a split or duplicate

FACILITY NAME:	ID NO:	DATE:	BORING/WELL NO.
LOCATION:	INSPECTOR/COMPANY:	GROUND ELEV:	TOTAL DEPTH:

DEPTH (FT)	SAMPLE TYPE/ NO*	SAMPLE RECOVERY (% OR RQD)	BLOWS/ 6 in.	DRILLING ACTIVITIES (METHOD DIAMETER REMARKS, ETC.)	PID READING (ppm)	SAMPLE/ STRATIGRAPHIC DESCRIPTION	GRAPHIC LOG (SHOW GW TABLE)	WELL DIAGRAM

*SAMPLE TYPES SS=SPLIT SPOON, ST=SHELBY TUBE R=ROCK CORE, O=OTHER	NOTES:	BORING NO.:

Figure 7F.1 Example Boring Log

soil sample. Split or duplicate samples may be analyzed in order to provide an order-of-magnitude verification of the primary sample analysis.

6. After retrieving the spoon, carefully remove the brass or stainless steel liners.

   The presence of noticeable hydrocarbon vapors or visual staining of the soil samples should be noted in the field notebook. The soil sample collected may be screened in the field for an initial determination of the presence or absence of contamination, or an order-of-magnitude estimate of the contaminant level, depending on the field screening equipment used. A discussion of the use of field screening equipment is included below. Based on the results of the field screening of the soil samples, samples to be analyzed in the analytical laboratory can be selected.

   Immediately cap the ends of the liner with Teflon sheeting and plastic end caps. There should be no headspace in the cylinders when they are capped. Secure the caps with Teflon tape (do not use duct or other tapes as they may contain volatile organic compounds which can contaminate the sample) and note the depth interval, sample number, and top and bottom ends of the sample liner.

7. Sample homogenization (i.e., collection of composite samples) should not be performed on samples intended for volatile or semivolatile organics analysis since the mechanical action of mixing exposes a larger surface area of the contaminated soils and other solids in the samples to the air, thus increasing the total amount of volatilization. Volatile organic analyses that are typically used for UST site characterization includes BTEX, TPH as gasoline, as well as organic lead analyses. (tetraethyl/tetramethyl lead compounds are volatile.)

8. Each sample should be labeled in sequence, then individually placed in watertight plastic bags to prevent cross-contamination. A chain of custody form and sample analysis request form should accompany each batch of samples to the laboratory.

   Complete the boring log noting date and time of collection of all samples, depth intervals, physical description of samples, and any other pertinent information.

9. When samples are being collected at the soil surface or on the sides or bottom of an excavation, about 1 inch of soil should be removed from the immediate surface area where the sample is to be taken and the cylinder then pounded into the soil with a wooden mallet. No headspace should be present in the cylinder once the sample is collected. When the sample has been collected, each end of the cylinder should be covered with Teflon sheeting and then capped with a plastic lid, taped, and labeled. The sample should then be immediately placed in a watertight plastic bag. Care should be taken throughout to avoid contamination of both the inside and outside of the cylinder and its contents.

10. All samples should be packed in a cooler with dry or blue ice in a manner that should prevent damage during transport to the analytical laboratory. Temperature during transport should be maintained at 4°C or below. A thermometer should be placed in the cooler.

    Samples should be kept at 4°C or below at the laboratory until they are analyzed. Holding time should not exceed 14 days from the time of collection. Frozen soil cores can be removed from the cylinders by spot heating the cylinder and immediately extruding the sample (or a portion of it). The sample should be prepared for analysis according to approved EPA methods.

Sampling Strategies for Soil Stockpiles

When the relative magnitude of contamination can be discerned through field screening methods (e.g., visual or olfactory observations, PID measurements, immunoassay tests, etc.) then stockpile sample locations should be biased towards areas of highest suspected contamination (biased or judgmental sampling). The intent of this sampling strategy is to ensure that hot spots of contaminated soil are detected and taken into account for final comparison to applicable soil action levels.

In cases where the physio-chemical characteristics of the contaminant or low contaminant concentrations render field screening impractical then non-biased sampling strategies may be appropriate. The intent of non-biased sampling strategies is to search for hot spots or determine average contaminant concentrations in the stockpile. Guidelines for both sampling strategies are provided below.

Procedures for Biased Sampling

Recommended Number of Samples

Unless otherwise approved or directed by DOH, stockpile soil samples should be collected and analyzed at a frequency of one sample per $20m^3$ of soil for the first $100m^3$ and one sample for each additional $100m^3$ of soil thereafter. (To convert cubic yards to cubic meters multiply by 0.765.) A minimum of two samples should be collected for stockpiles containing less than $40m^3$ of soil.

Sampling Methods

Proper methods for collecting soil samples during a site investigation and during stockpile sampling are described in the DOH TGM (HIDOH, 1992). As noted in the TGM, soil samples that are to be tested for volatile compounds (Henry's Law Constant > 0.00001 atm-m^3/mol and molecular weight < 200 gm/mol) should be collected using brass or steel cylinders that are forcibly driven into the soil. This is intended to ensure that the samples are disturbed as little as possible during collection in order to help reduce the loss of volatile compounds prior to analysis. For the same reason, soil samples that are to be tested for volatile compounds should **not** be composited, either in the field or by the laboratory (Table 1). This applies to soil samples collected for the purpose of both site investigations and stockpile sampling.

Stockpile samples should be collected from depths greater than 15 cm (6 inches) below the surface of the pile. Collection of soil samples in glass jars during either a site investigation or sampling of a stockpile is recommended only in cases where metal cylinders cannot be used. When possible, the glass jars should be pushed into the soil to collect the sample rather than using a trowel to scoop the soil into the jar. Soil should be manually scooped into a brass cylinder or jar only when the nature of the soil makes the recommended procedure impossible (e.g., large rock fragments, dry hard soil, etc.). Justification should be provided in the text of the report if alternative methods of soil sampling such as this are used.

PAH Analyses

A comparison of data submitted for diesel-contaminated soils demonstrated that the concentration of polynuclear aromatic hydrocarbon compounds (PAHs) in soil with very low concentrations of Total Petroleum Hydrocarbons as diesel (TPH-diesel) is consistently well below DOH action levels. In order to reflect this experience and to help minimize unnecessary sample analysis costs, DOH is no longer requiring PAH analyses of diesel-impacted soils when the corresponding concentration of TPH-diesel is 10 mg/kg or less (typical detection limit for TPH-diesel). This policy applies only to sites where contamination is known to be restricted to diesel fuel (or other middle distillates) or diesel fuel plus gasolines. The policy does not apply to sites contaminated with heavy fuels or to sites where the contaminant source is unknown.

In addition, DOH is allowing an assumption that soil samples with the highest detected TPH levels can also be reasonably expected to contain the highest concentration of PAHs. At this point in time this assumption is being applied only to PAHs. For stockpiles where polynuclear aromatic hydrocarbons (PAHs) are included as contaminants of concern, a minimum of one sample or 20% of the total number of samples collected, whichever is greater, should be analyzed for PAHs. (Numbers should be rounded up.) The sample(s) chosen for analysis should be reflective of the highest concentrations of total petroleum hydrocarbons (TPH) detected in the soil pile. This same strategy should also be applied for testing soil samples collected in-place during site investigation activities.

Confirmatory Contaminant Concentrations

Unless otherwise approved or directed by DOH, the maximum contaminant concentration detected in a soil stockpile should be used for final comparison to applicable soil action levels. As a general rule, but subject to discussions with DOH, hot spots should not be diluted by mixing with other soil. In some cases it may be appropriate to separate detected hot spots from soil that is not contaminated above applicable action levels in order to reduce remediation costs.

Procedures for Non-Biased Sampling

In cases where the physical nature of a contaminant (e.g., low volatility, low concentration, etc.) and available technology prohibits effective detection of hot spots through field screening, the stockpile should be sampled using non-biased sampling techniques in accordance with published guidelines (e.g., USEPA, 1986; USEPA 1991a, Pitard, 1993). The intent of this sampling scheme is to evaluate the **average** contaminant concentration in a stockpiled soil versus to delineate and evaluate hot spots as discussed earlier. Guidance on appropriate sampling methods and PAH analyses presented in the previous section should be applied to non-biased sampling programs as appropriate.

The minimum number of samples to be initially collected should be based on the volume of the stockpile, in accordance with the guidance presented in the earlier section. The need to collect additional samples from the stockpile should be statistically evaluated (refer to guidelines provided in Chapter Nine of *Test Methods for Evaluating Solid Waste* (USEPA,1986), if possible, and/or further discussed with DOH. In some cases it may be preferable to thoroughly mix and homogenize the stockpiled soil prior to sampling in order to reduce the variance between sample results and provide a more accurate representation of average contaminant concentrations in the stockpile as a whole. Be aware, however, that mixing highly-contaminated hot spots with otherwise "clean" soil could potentially increase the volume of soil that exceeds DOH-recommended action levels and therefore increase remediation costs.

In cases where the analytical data are shown to be statistically representative of the stockpile as a whole, the 95th percent, upper confidence limit of the arithmetic mean of the sample results should be used for final comparison to applicable soil action levels. Refer to Chapter 6, Section 4, in *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)* (USEPA, 1989) for additional guidance on the quantification of contaminant concentrations in impacted soils.

WATER SAMPLING

Surface Water Sampling

Representative concentrations of the contaminants of interest in water samples should be assured by taking the following precautions in obtaining field samples.

1. Prior to the initial sampling, decontamination procedures should be followed on all equipment, as outlined in the Soil Sampling Procedures section above, to prevent the introduction of contaminants by outside sources.

2. Samples from shallow depths can be readily collected by merely submerging the sample container. The container's mouth should be positioned so that it faces upstream, while the sampling personnel are standing downstream so as not to stir up any sediment that may contaminate the sample.

3. To avoid aeration of the sample, the sample container should be held at an angle so that the stream of water flows down the side. The sample container should be filled until it overflows and the lid carefully screwed on. Zero headspace in the sample container should be ensured by inverting the vial and carefully tapping on the cap. If air bubbles appear, remove the cap and add enough sample water to produce an inverted meniscus. Cap and repeat the check for air bubbles.

4. Collecting a representative sample at depth or from a larger body of surface water is difficult but not impossible. Samples should be collected near the shore if possible. If boats are used, the body of water should be cross-sectioned, and samples should be collected at various depths across the water in accordance with the specified sample location plan. For this type of sampling, a weighted-bottle sampler is used to collect samples at any predetermined depth. The sampler consists of a glass bottle, a weighted sinker, a bottle stopper,

and a line that is used to open the bottle and to lower and raise the bottle during sampling. The procedure for use is as follows:

a. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely.

b. Pull out the stopper with a sharp jerk of the sampler line.

c. Allow the bottle to fill completely, as evidenced by the cessation of air bubbles.

d. Raise the sampler and cap the bottle.

e. Wipe the bottle clean. The bottle can also be used as the sample container.

5. Samples for volatiles should be placed in three 40 mL volatile organic analysis (VOA) bottles provided by the analytical laboratory. These sample bottles are screw-top vials with Teflon-lined silicone septa. Sample bottles should not be rinsed prior to sampling, and should be placed in the ice chest immediately after labeling.

6. Duplicate samples, when collected, should be taken immediately after the field sample. Decontamination procedures are not necessary between sampling for the field sample and the duplicate.

7. Field samples, field duplicates, and trip blanks should be labeled in sequence and individually placed in plastic bags to prevent cross-contamination. Chain of custody and sample analysis request forms should accompany each shipment of samples to the laboratory, listing the analyses to be performed and the QA/QC criteria for laboratory duplicates and matrix spikes. All samples should be packed in a cooler on blue ice (at 4°C) in such a way as to prevent breakage. A thermometer should be placed in the cooler during transport.

<u>Groundwater Sampling</u>. Groundwater samples should be obtained from monitoring wells in accordance with the procedures set forth in this section. All monitoring wells intended for use in groundwater sampling programs are required to be designed and constructed in accordance with Department of Health (DOH) guidelines set forth in this section and the HIDOH document titled draft *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan* dated December 1996. An example groundwater monitoring well construction design is provided in Figure 7E.2. DOH does not set restrictions on the minimum

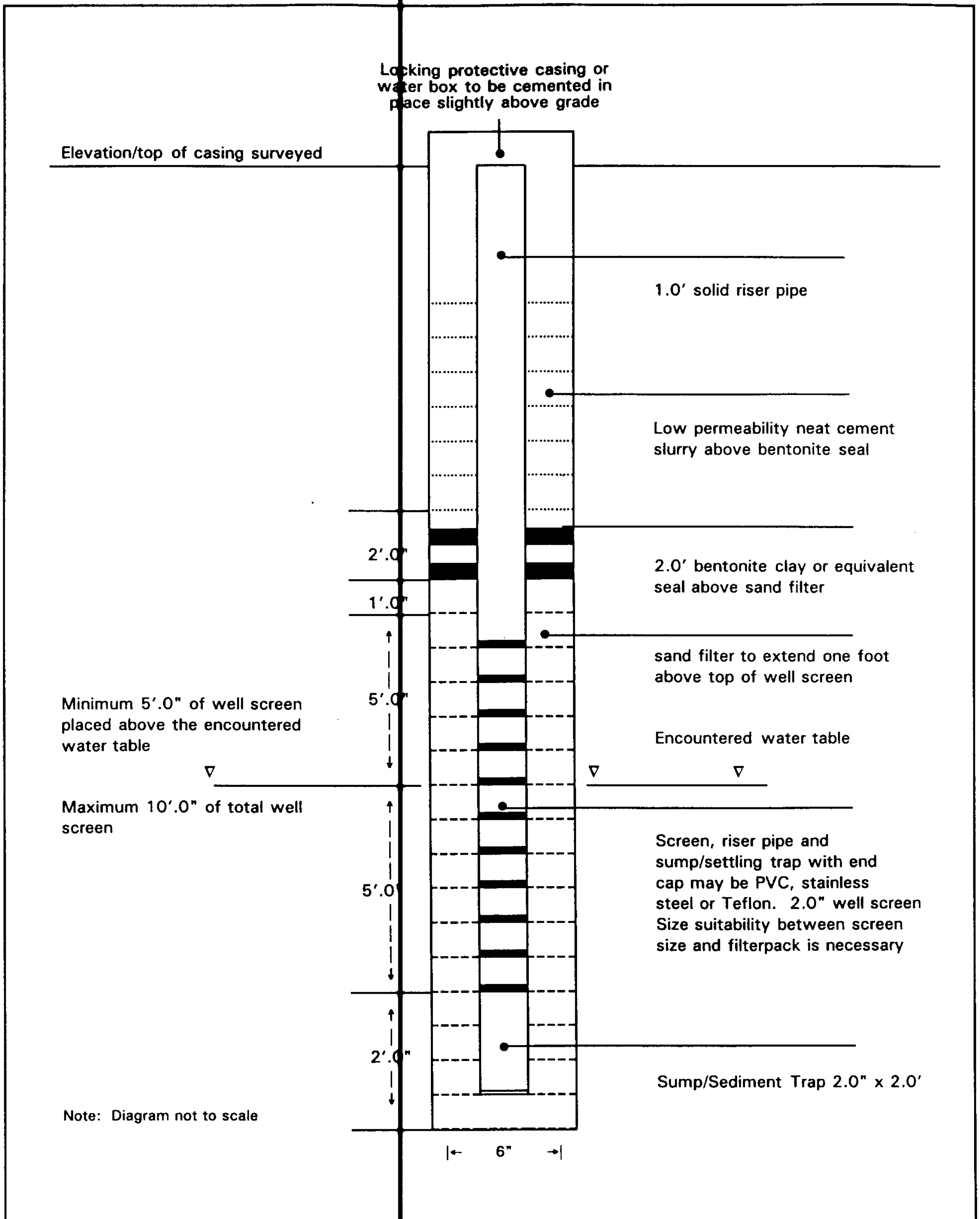

Figure 7E.2 Example Ground-water Monitoring Well Construction Detail

allowable diameter of a monitoring well provided that the well is constructed in accordance with the above-stated guidelines. While the diameter of a monitoring well strongly effects the present and future **utility** and **efficiency** of the well, DOH does not consider well diameter to cause a significant negative bias on the **quality** of groundwater samples extracted from the well, provided that standard sampling procedures are adhered to. DOH also does not place restrictions on the use of push-type devices (e.g., Geoprobe, Stratoprobe, etc.) to install small-diameter monitoring wells, again provided that the wells are designed and constructed in accordance with DOH-recommended guidelines.

As noted, small-diameter wells have distinct advantages but site-specific considerations must be taken into account before deciding on the well diameter most appropriate for a given site. Problems reported to DOH regarding the use of small-diameter wells include difficulties in installing wells in soils or sediments with intermixed, consolidated rock; difficulties in obtaining adequate sample volumes in low permeability soils or sediments; clogging of wells over time; and difficulties in locating the vadose-zone/groundwater interface so that well screens can be properly positioned.

Monitoring wells should be constructed in accordance with the specifications provided in Figure 7E.2. Wells should be developed (bailed, pumped, surged) until a constant minimum turbidity is achieved. Excessive turbidity of water removed from a well may affect sample integrity and may indicate improper well installation. Monitoring well placement should be specified in the sample location plan.

Filtering of Groundwater Samples

Unless otherwise directed by DOH, groundwater samples that are to be tested for non-volatile constituents (Henry's Law Constant $\leq 10^{-5}$ atm-m^3/mol and a molecular weight $\geq$ 200 grams/mol) should be filtered if there is any evidence of turbidity in the samples (e.g., turbidity > 5 NTU), refer to Table 7E.1. Turbidity should be measured in the field during sampling as needed. Filtering of the samples should take place prior to the addition of a preservative in order to prevent leaching of otherwise sorbed-phase contaminants from suspended sediment. Filter pore sizes should be no smaller than 0.45 microns. The methods and equipment used to filter groundwater samples should be clearly described in the text of the groundwater sampling report presented to DOH for review and incorporation into the public file for the facility.

Filtering of samples that are to be tested for volatile contaminants (Henry's Law Constant $> 10^{-5}$ atm-m^3/mol and a molecular weight < 200 gm/mol) should be avoided in order to minimize the loss of contaminants due to volatization during sampling. Based on published partitioning data for low molecular weight, non-surface reactive contaminants (e.g., volatile compounds), the contribution of

Contaminant	[2]Volatile?		[3]OK to Composite Soil Samples?	[4]OK to Filter Groundwater Samples?	OK to Collect Sample With Vacuum-Type Pump?
[1]COMMON UST-RELATED CONTAMINANTS					
Benzene	yes		NO	NO	[5]YES(see note)
Toluene	yes		NO	NO	[5]YES(see note)
Ethylbenzene	yes		NO	NO	[5]YES(see note)
Xylene (mixed)	yes		NO	NO	[5]YES(see note)
Benzo(a)pyrene	no		YES	YES	YES
Acenaphthene	yes		NO	NO	[5]YES(see note)
Fluoranthene	no		YES	YES	YES
Naphthalene	yes		NO	NO	[5]YES(see note)
PCE	yes		NO	NO	[5]YES(see note)
1,1 DCE	yes		NO	NO	NO
Vinyl Chloride	yes		NO	NO	NO
TCE	yes		NO	NO	[5]YES(see note)
1,1,1 TCA	yes		NO	NO	[5]YES(see note)
PCBs (1260 Arochlor)	no		YES	YES	YES
TPH-residual fuels	no		YES	YES	YES
TPH-middle distillates	yes		[6]NO (see note)	[6]NO (see note)	YES
TPH-gasolines	yes		[6]NO (see note)	[6]NO (see note)	YES
[7]OTHER CONTAMINANTS					
Acetone	yes		NO	NO	[5]YES(see note)
Chlorobenzene	yes		NO	NO	[5]YES(see note)
Chloroform	yes		NO	NO	[5]YES(see note)
4,4 DDD	no		YES	YES	YES
4,4 DDE	no		YES	YES	YES
4,4 DDT	no		YES	YES	YES
Di-n-octyl phthalate	no		YES	YES	YES
Ethylene glycol	no		YES	YES	YES
Methylene chloride	yes		NO	NO	[5]YES(see note)
2,3,7,8 TCDD (Dioxin)	no		YES	YES	YES
Chlordane	no		YES	YES	YES
Carbon tetrachloride	yes		NO	NO	[5]YES(see note)

1. Refer to recommended chemical analysis for UST closure and release response (Table 7.2, DOH Technical Guidance Manual - August 1992).
2. Defined as Henry's Law Constant > 0.00001 m^3-atm/mole and molecular weight < 200 gm/mol.
3. For biased-sampling actions, analytical results from composited samples should be multiplied by the number of samples composited to determine the maximum possible contaminant concentration in any one sample. This adjusted value should be used for comparison to applicable DOH action levels.
4. Minimum filter size 0.45μ.
5. Multiply laboratory analytical results by a factor of two for volatile contaminants.
6. Soil and groundwater samples to be tested for TPH may be composited or filtered for release verification purposes only. Any detection of TPH in the samples constitutes a release and requires followup action.
7. Contact DOH for information on contaminants not listed.

Table 7E.1 Allowance for Compositing Soil Samples

sorbed or colloidal phases of these contaminants to total contaminant concentration can be expected to be insignificant. If the collection of highly turbid groundwater samples cannot be avoided at a site (e.g., due to the placement of the monitoring well in clayey, oversaturated lagoonal sediments), then an in-line filter should be used to minimize sample disturbance. Again, this should be clearly described and justified in the text of the report.

Water Level Measurements. Water level measurements are routinely required as part of the sampling program. Collection of water elevations on a continuing basis is important for determining if horizontal and vertical flow gradients have changed since the initial site characterization. A change in hydrologic conditions may necessitate modifications in the design of the ground-water monitoring system or of the corrective action technology being implemented.

The field measurements should include depth to standing water and total depth of the well. This information is required to calculate the volume of stagnant water in the well and to provide a check on the integrity of the well (e.g., identify siltation problems). Each well should have a permanent, easily identified reference point from which its water level measurement is taken. The reference points should be established by an accurate survey and typically located and marked at the north side and top of the well casing with the locking cap removed or on the apron, and, where applicable, the protective casing.

Measure the static water level before removing water from the well for purging or sampling. The well should be allowed to stabilize for a minimum of 24 hours after development of the well or any other withdrawal procedures before a water level measurement is taken. The device used to detect the water level surface must be sufficiently sensitive so that a measurement to $\pm$0.01 foot can be reliably obtained. The water level reading should be recorded on the ground-water sampling data sheet in Figure 7E.3. Three methods of measuring the water level in a well are described below:

1. Electric tape

   Note: The electric tape method should not be used in wells containing free product unless electrical connections are intrinsically safe (explosion proof).

   a. Turn on the switch. Check the batteries by inserting the probe (the tip) into water and noting if the contact between the probe and the water surface is registering clearly.

   b. Rinse the probe with distilled water.

SITE INFORMATION:

Site Name, Date:

Location: ____

UST Facility ID Number: ___ -- ___ ___ ___ ___ ___ ___   Owner/Operator: ____________

SAMPLER INFORMATION:

Name: ________________________ Phone Number: ____________________

Organization: ____

WELL INFORMATION:

Well Number: __________ Well Location: ______________________________

Depth to Water: _____ ft. Depth of Well: _____ ft. Water Column Height: __________ ft.

Well Diameter: __________ in.

VOLUME OF WATER TO BE REMOVED DURING PURGING:

V = * (D) 2 * 0.041
V = one well volume (gal)
H = height of water column (ft)
D = inside diameter of well (in.)

Well volume, V = ________ gal

V * 3 well volumes = __________ gal V * 5 well volumes = __________ gal

COLLECT SPECIFIC CONDUCTIVITY, TEMPERATURE AND pH MEASUREMENTS INITIALLY AND AFTER EVERY WELL VOLUME IS PURGED

TIME	SPEC. COND.	TEMP	pH	COMMENTS

SAMPLE INFORMATION:

Sample numbers:		Time of Collection:		Total Pre-Sampling Time:

Figure 7E.3 Ground-water Sampling Data Sheet

c. Slowly lower the probe into the well by pulling cable from the hand-held reel.

d. Continue lowering until the bulb lights up, the beeper beeps, or the ammeter needle deflects, indicating that the water table has been reached.

e. Measure the length of cable in the well from a datum point (the top of the casing) or other reference point (look for a mark on or in the casing or some type of "v" etched into the casing) to the nearest 0.01 foot. Subtract this length (depth to the water table) from the reference elevation to determine the water level elevation.

f. Raise the probe until contact with the water has been broken. Lower the probe once again in order to check the measurement reading.

g. Rinse the cable and probe with distilled water.

Note: Multiphase probes are available which audibly indicate the relative position of both nonaqueous phase liquids and aqueous phase liquids. Operation is similar to that of the single phase electric tape probe discussed above.

2. Popper

a. Measure the length of the popper.

b. Rinse the line and popper with distilled water.

c. Lower the popper into the well.

d. Listen for the "pop." You may have to raise and lower the popper several times to make sure you have found the water level.

e. Read the tape measurement from a datum point (the top of the casing) or other prescribed point (look for a mark on or in the casing or some type of "v" etched into the casing) to the nearest 0.01 foot. Add the length of the popper to arrive at the depth to water.

f. Raise the tape approximately 1 foot. Lower the tape once again and repeat steps "d" and "e" in order to check the reading.

g. Subtract the depth to water from the reference point elevation to obtain the water level elevation.

h. Rinse the line and popper with distilled water.

3. Coated tape

Note: The coated tape usually has a weight attached to the end, and it may be necessary to add or subtract the length of the weight from the total water level elevation. Know which type of tape measuring device you intend to use before going into the field.

a. Rinse the lower few feet of the tape with distilled water and dry.

b. Chalk the lower few feet of the tape by drawing the tape across a piece of colored carpenter's chalk.

c. Lower the tape into the well until you hear or feel the tape reach the water surface. Lower the tape a few inches into the water.

d. Read the tape measurement from a datum point (the top of the casing) or other prescribed reference point (look for a mark on or in the casing or some type of "v" etched into the casing) to the nearest 0.01 foot. Record the reading.

e. Withdraw the tape from the well and observe the lower end of the tape. The demarcation between the wetted and unwetted portions of the chalked tape should be apparent.

f. Subtract this value (item d) from the elevation of the top of the casing (from reading item c). This difference is the depth to the water surface.

g. Subtract the depth to water from the elevation at the top of the casing to obtain the water level elevation.

h. Record the well location and number, depth to groundwater, depth to bottom of the monitoring well, reference point used, and other pertinent data on the groundwater sampling data sheet.

i. Rinse the tape with distilled water.

If the presence of free product is indicated, the thickness of the free product layer can be determined using a tape coated with water and hydrocarbon indicator pastes or an intrinsically safe electronic interface probe. In the case of the former, a steel tape coated with water indicator paste on one side and hydrocarbon indicator paste on the other is lowered into the monitoring well. This should be done so there is as little disturbance of the water surface as possible. The hydrocarbon indicator paste should coat a length of the steel tape that is 2 to 4 inches greater than the estimated thickness of the product. The thickness of the product is measured to the nearest 0.01 foot. As for the interface probe, this instrument is operated similarly to the electric tape device explained above except a different signal should result when product is encountered.

All equipment should be constructed of inert materials and should be decontaminated prior to use at another well to avoid cross- contamination.

Well Purging. The goal in sampling ground-water monitoring wells is to obtain samples that are representative of the aquifer or ground water in question. A representative sample is a volume of water taken from a well whose physical and chemical properties are accurately interpreted to be indicative of conditions in the ground water. Water that stands within a monitoring well for a long period of time may become unrepresentative of the ground water because chemical change may cause water quality alterations. Even if the stored water in the monitoring well may be unchanged from the time it entered the well, the stored water may not be representative of ground water at the time of sampling. In order to obtain a representative sample, the stored water must be removed, or purged, from the monitoring well before samples are collected. The following procedures should be followed for purging monitoring wells.

1. Wells screened in low permeability formations (wells that can be purged dry):

   a. Pump or bail the well dry.

   b. Allow the well to recover after purging.

   c. Purge the well a second time, if time permits.

   d. Collect the sample as soon as there is a sufficient volume of water for the intended analyses; the well does not need to fully recover.

2. Wells screened in high permeability formations:

   a. Pump or bail three to five well volumes.

   b. Do not pump a well dry if the recharge rate causes the formation water to vigorously cascade down the sides of the screen and causes an accelerated loss of volatiles. Purge the well volumes at a rate that does not cause recharge water to be excessively agitated.

c. Test the ground water for pH, temperature, and specific conductance (see the Field Measurements section below for sampling procedures) after every well volume, or after every 10 minutes, whichever comes first. The pH, temperature, and specific conductance should stabilize with time. This stabilization indicates that water is now being drawn from the aquifer and not from the vincity of the casing. If stabilization occurs before pumping or bailing three to five well volumes, continue to pump or bail until three to five complete well volumes have been purged.

d. Introduce as little air and turbulence into the formation as possible in order to prevent alteration of the samples.

Calculation of the well volume is accomplished by using the following formula:

$$V = (H)(D^2)(C)$$

where:
- V = one well volume, gallons
- H = height of water column, feet
- D = inside diameter of well, inches
- C = 0.041 gallons/(inches)^2 (feet)

The volume in gallons calculated by the above equation must be multiplied by the number of well volumes necessary to adequately purge the well.

Purging of monitoring wells can be accomplished with Teflon or stainless steel PVC bailers or with bladder, peristaltic, gas-lift, centrifugal, or venturi pumps. All pump components that may be exposed to the water, including the discharge tubing, should be constructed of Teflon, stainless steel, or PVC. Some of these pumps cause volatilization and produce high pressure differentials, which result in variability in the analysis of pH, specific conductance, metals, and volatile organic samples. They are, however, acceptable for purging the wells if sufficient time is allowed to let the water stabilize prior to sampling. Do not use purged water for samples since the water is aerated in the purging process.

When purging equipment must be reused, it should be decontaminated, following the same procedures as those required for the sampling equipment. Steps should be taken to prevent surface soils from coming into contact with the purging equipment and lines, which could introduce contaminants into the well. The purged ground water must be stored in a specified waste drum until the water samples are analyzed and appropriate disposal procedures are determined. The purged water may NOT be dumped on the ground.

Field Measurement Procedures

Several water quality parameters are subject to rapid change when the groundwater is removed from its natural environment and exposed to the atmosphere. Therefore, temperature, specific conductance, and pH must be measured on an unfiltered sample at the time of sample collection.

Field personnel should familiarize themselves with the manufacturer's instructions for use of the pH, temperature, and/or specific conductance meter(s) before going to the field and collecting samples. Calibration of any field-test probes or kits should be done at the beginning of each use according to the manufacturer's specifications.

Temperature.

1. Rinse the thermometer or temperature meter probe with distilled water.

2. Immerse the thermometer or probe into the sample. The thermometer or probe must not be placed in sample containers containing ground-water samples for laboratory analysis.

3. Wait for the temperature reading to stabilize (this may take about a minute).

4. Read and record the temperature to the nearest 0.5°C (or °F). Read the thermometer while it is immersed in the sample.

5. Rinse the thermometer or probe with distilled water.

Specific Conductance.

1. Set up and calibrate the conductivity meter according to the manufacturer's instructions.

2. The specific conductance cell can become coated with oil and other materials. It is essential that the cell be thoroughly rinsed and, if necessary, cleaned between samples.

3. Set the range selector to the desired range for measurement.

4. Measure the temperature of the sample with a thermometer (as above) and set the temperature selector on the conductivity meter to the measured temperature (if required). Whenever possible, samples should be analyzed at 25°C. If samples are analyzed at different temperatures, temperature corrections must be made and resulting specific conductance reading reported at 25°C.

5. Rinse the probe with distilled water.

6. Place the probe into the sample and move it up and down several times to remove the air bubbles inside the cell casing. Rotate the cell slowly in the sample until the reading stabilizes (some meters may require different procedures).

7. Read and record the conductivity measurement. Remember to multiply the reading by the range the dial is set to (see No. 2).

8. Rinse the probe with distilled water.

9. If necessary, correct the measurement to the standardized 25°C.

pH.

1. Set up and calibrate the pH meter with the proper buffer solution according to the manufacturer's instructions.

2. Rinse the electrode thoroughly with distilled water. Coatings of oily material or particulate matter can impair electrode response. These coatings can usually be removed by gentle wiping or detergent washing, followed by rinsing with distilled water. An additional treatment with hydrochloric acid (1:9) may be necessary to remove any remaining film.

3. Immerse the electrode into the sample and if possible gently swirl.

4. Wait for the reading to stabilize.

5. Read and record the pH to the nearest 0.1 unit.

6. Remove the electrode from the sample and rinse the electrode with distilled water.

7. Store the electrode in the buffer solution (following the manufacturer's recommended storage procedure). The electrode should never be allowed to dry out, since it could damage the electrode.

Sampling Procedures. Special care must be taken in order to prevent cross-contamination when carrying sampling equipment from one well to another. The sampling equipment must be cleaned thoroughly prior to sampling each monitoring well. The effects of cross contamination can be minimized by sampling the least contaminated wells first and progressing to the more contaminated ones. Dedicated sampling devices for each well may be desirable in certain cases where the potential for cross-contamination is extremely high.

The decontamination procedure is as follows:

1. Steam clean or scrub equipment with a nonphosphate detergent.

2. Rinse twice with distilled water.

Equipment and procedures that minimize sample agitation and reduce or eliminate contact with the atmosphere during sample transfer must be used in order to eliminate the loss of volatile constituents from the sample. For collecting samples, a Teflon or stainless steel bailer is acceptable as is a gas-actuated positive displacement pump or a submersible pump. Airlift pumps should not be used. Sampling equipment should be constructed of inert materials. Equipment with neoprene fittings, PVC bailers, tygon tubing, silicon rubber bladders, neoprene impellers, polyethylene, and viton are not acceptable. If bailers are used, an inert line, cable, or chain should be used to raise and lower the bailer.

Vacuum-type (e.g., peristaltic) pumps may be used to collect groundwater samples with the following constraints: 1) the pump is operated at a low flow rate (generally < 200ml/minute); 2) contaminants of concern must have a Henry's Law Constant of less than or equal to 0.03 atm-m^3/mol (refer to Table 7E.2); and 3) a 50% sampling loss is assumed for volatile contaminants. Unless otherwise directed or approved by DOH, concentrations of volatile contaminants should be reported as the laboratory analytical results for the contaminant multiplied by two (i.e., following the assumption that 50% of the contaminant was lost during the sample collection).

When sampling for volatile organics, evaluate the area around the sampling point prior to sample collection for possible contamination from air routes. Products that may contaminate the ground-water samples include perfumes, cosmetics, suntan lotions, and automotive products such as gasoline, starting fluids, and carburetor cleaners. Avoid contact of sampling equipment with surface soils surrounding the monitoring wells. Sampling equipment may be laid on polyethylene sheeting.

Before collecting the water sample, mark the sample bottles to be used for the ground-water sample with a waterproof pen. Label the bottle with the name, or identification, of the monitoring well, the date, time the sample was collected, and the sampler's name.

Samples for volatiles should be placed in three 40 mL VOA bottles provided by the analytical laboratory. These sample bottles are screw-top vials with Teflon-lined silicone septa. Sample bottles should not be rinsed prior to sampling.

Procedures for sampling using bailers:

1. Put on latex or surgical gloves.

2. Rinse the bailer and line with distilled water. Use of a disposable bailer and new line at each sampling interval is preferred.

3. Lower the bailer slowly into the monitoring well. Once the bailer has contacted and entered the ground water, allow the bailer to fill with the ground-water sample.

4. Gently raise the bailer out of the monitoring well (do not allow the bailer rope to touch the ground--use plastic sheeting).

5. Empty the bailer into the sample bottles, using a slow, steady stream. Open, or uncap, one volatile organics analyses vial at a time. Fill the VOA vial so that it is slightly overflowing and a positive, or convex, meniscus is formed. Cap immediately. Turn the VOA vial upside down and tap the vial gently. Check for air bubbles. If air bubbles are found, uncap bottle and allow gas to escape, then create a positive meniscus. The bottle should be emptied and refilled as the preservative would be lost. Keep trying until no air bubbles are found in the VOA vial. Any air bubbles in the VOA vial could aerate the sample and void the analysis.

6. Duplicate samples, when collected, should be taken immediately after the field sample.

7. Record all pertinent sampling data on the ground-water sampling data sheet (Figure 7E.3).

8. Decontaminate the bailer. Cut off and discard any of the line that came in contact with the ground water. Decontaminate the remaining line.

9. Place the sample bottles in baggies to prevent cross contamination. If the sample is highly contaminated, wrap the sample bottle in aluminum foil before placing in a baggie.

10. Place the samples in a 4°C cooler with ice. VOA vials may get too cold when they are placed against the ice, and may freeze and crack. Therefore, care should be taken when placing the VOA vials inside the cooler. A thermometer should be placed in the cooler during transport.

11. Carefully remove gloves. Do not touch the outside of the gloves where they may have been contaminated by the ground water. Place the gloves in a designated garbage bag, or a baggie, for proper disposal. Gloves should be changed for each sampling site.

The procedure for sampling using bladder pumps is the same as the procedure for bailers with the exception of the following steps:

1. Positive gas displacement bladder pumps should be operated in a continuous manner so that they do not produce pulsating samples that are aerated in the return tube or upon discharge.

2. When collecting samples where volatile constituents or gases are of interest using a positive gas displacement bladder pump (or a submersible pump), pumping rates should not exceed l00 mL/minute. Higher rates can increase the loss of volatile constituents and can cause fluctuation in pH and pH-sensitive analytes. Samples should be placed in an ice chest maintained at 4°C with blue ice. A thermometer with a protected bulb should be carried in each ice chest.